



# Fabrication of Single Crystal MgO Capsules

*Lyndon B. Johnson Space Center, Houston, Texas*

A method has been developed for machining MgO crystal blocks into forms for containing metallic and silicate liquids at temperatures up to 2,400 °C, and pressures up to at least 320 kilobars. Possible custom shapes include tubes, rods, insulators, capsules, and guides. Key differences in this innovative method include drilling along the crystallographic zone axes, use of a vibration minimizing material to secure the workpiece, and constant flushing of material swarf with a cooling medium/lubricant (water).

A single crystal MgO block is cut into a section  $\approx 5$  mm thick, 1 cm on a side,

using a low-speed saw with a 0.004 blade. The cut is made parallel to the direction of cleavage. The block may be cut to any thickness to achieve the desired length of the piece. To minimize drilling vibrations, the MgO block is mounted on a piece of adhesive putty in a vise. The putty wad cradles the bottom half of the entire block. Diamond coring tools are used to drill the MgO to the desired custom shape, with water used to wet and wash the surface of swarf. Compressed air may also be used to remove swarf during breaks in drilling. The MgO workpiece must be

kept cool at all times with water. After all the swarf is rinsed off, the piece is left to dry overnight.

If the workpiece is still attached to the base of the MgO block after drilling, it may be cut off by using a diamond cut-off wheel on a rotary hand tool or by using a low-speed saw.

*This work was done by Lisa Danielson of Jacobs Technology for Johnson Space Center. For more information, download the Technical Support Package (free white paper) at [www.techbriefs.com/tsp](http://www.techbriefs.com/tsp) under the Manufacturing & Prototyping category. MSC-25052-1*



# Monitoring of International Space Station Telemetry Using Shewhart Control Charts

This technique can be applied to monitoring critical systems such as electrical power generation and manufacturing equipment.

*Lyndon B. Johnson Space Center, Houston, Texas*

Shewhart control charts have been established as an expedient method for analyzing dynamic, trending data in order to identify anomalous subsystem performance as soon as such performance would exceed a statistically established baseline. Additionally, this leading indicator tool integrates a selection methodology that reduces false positive indications, optimizes true leading indicator events, minimizes computer processor unit duty cycles, and addresses human factor concerns (i.e., the potential for flight-controller data overload). This innovation leverages statistical process control, and provides a relatively simple way to allow flight controllers to focus their attention on subtle system changes that

could lead to dramatic off-nominal system performance. Finally, this capability improves response time to potential hardware damage and/or crew injury, thereby improving space flight safety.

Shewhart control charts require normalized data. However, the telemetry from the ISS Early External Thermal Control System (EETCS) was not normally distributed. A method for normalizing the data was implemented, as was a means of selecting data windows, the number of standard deviations (Sigma Level), the number of consecutive points out of limits (Sequence), and direction (increasing or decreasing trend data). By varying these options, and treating them like dial settings, the num-

ber of nuisance alerts and leading indicators were optimized. The goal was to capture all leading indicators while minimizing the number of nuisances. Lean Six Sigma (L6S) design of experiment methodologies were employed. To optimize the results, Perl programming language was used to automate the massive amounts of telemetry data, control chart plots, and the data analysis.

*This work was done by Jeffery T. Fitch, Alan L. Simon, John A. Gouveia, Andrew M. Hillin, and Steve A. Hernandez of United Space Alliance for Johnson Space Center. For more information, download the Technical Support Package (free white paper) at [www.techbriefs.com/tsp](http://www.techbriefs.com/tsp) under the Information Technology category. MSC-24530-1*



# Nonhazardous Urine Pretreatment Method

**This method can be used as a means for safe urine storage on ships, planes, and recreational vehicles, or in conjunction with portable restrooms.**

*Lyndon B. Johnson Space Center, Houston, Texas*

A method combines solid phase acidification with two non-toxic biocides to prevent ammonia volatilization and microbial proliferation. The safe, non-oxidizing biocide combination consists of a quaternary amine and a food preservative. This combination has exhibited excellent stabilization of both acidified and unacidified urine.

During pretreatment tests, composite urine collected from donors was challenged with a microorganism known to proliferate in urine, and then was processed using the nonhazardous urine pre-treatment method. The challenge microorganisms included *Escherichia coli*, a common gram-negative bacteria; *Enterococcus faecalis*, a ureolytic gram-positive bacteria; *Candida albicans*, a yeast commonly found in urine; and *Aspergillus niger*, a problematic mold that resists urine pre-treatment.

Urine processed in this manner remained microbially stable for over 57

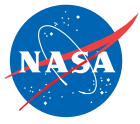
days. Such effective urine stabilization was achieved using non-toxic, non-oxidizing biocides at higher pH (3.6 to 5.8) than previous methods in use or projected for use aboard the International Space Station (ISS). ISS urine pretreatment methods employ strong oxidants including ozone and hexavalent chromium (Cr(VI)), a carcinogenic material, under very acidic conditions (pH = 1.8 to 2.4).

The method described here offers a much more benign chemical environment than previous pretreatment methods, and will lower equivalent system mass (ESM) by reducing containment volume and mass, system complexity, and crew time needed to handle pretreatment chemicals. The biocides, being non-oxidizing, minimize the potential for chemical reactions with urine constituents to produce volatile, airborne contaminants such as cyanogen chloride. Additionally, the biocides are active under significantly less acidic con-

ditions than those used in the current system, thereby reducing the degree of required acidification.

A simple flow-through solid phase acidification (SPA) bed is employed to overcome the natural buffering capacity of urine, and to lower the pH to levels that fix ammoniacal nitrogen in the non-volatile and highly water soluble  $\text{NH}_4^+$  form. Citric acid, a highly soluble, solid tricarboxylic acid essential to cellular metabolism, and typically used as a food preservative, has also been shown to efficiently acidify urine in conjunction with non-oxidizing biocides to provide effective stabilization with respect to both microbial growth and ammonia volatilization.

*This work was done by James R. Akse and John T. Holtsnider of Umpqua Research Company for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809. MSC-24520*



# Radiation-Tolerant DC-DC Converters

*Lyndon B. Johnson Space Center, Houston, Texas*

A document discusses power converters suitable for space use that meet the DSCC MIL-PRF-38534 Appendix G radiation hardness level P classification. A method for qualifying commercially produced electronic parts for DC-DC converters per the Defense Supply Center Columbus (DSCC) radiation hardened assurance requirements was developed.

Development and compliance testing of standard hybrid converters suitable

for space use were completed for missions with total dose radiation requirements of up to 30 kRad. This innovation provides the same overall performance as standard hybrid converters, but includes assurance of radiation-tolerant design through components and design compliance testing. This availability of design-certified radiation-tolerant converters can significantly reduce total cost and delivery time for power converters

for space applications that fit the appropriate DSCC classification (30 kRad).

*This work was done by Glenn Skutt, Dan Sable, Leonard Leslie, and Shawn Graham of VPT, Inc. for Johnson Space Center. **For more information, download the Technical Support Package (free white paper) at [www.techbriefs.com/tsp](http://www.techbriefs.com/tsp) under the Electronics/Computers category.** MSC-24497-1*



# Method and Apparatus for Automated Isolation of Nucleic Acids from Small Cell Samples

**Advantages include reduced or eliminated use of toxic reagents and operator-independent extraction.**

*Lyndon B. Johnson Space Center, Houston, TX*

RNA isolation is a ubiquitous need, driven by current emphasis on microarrays and miniaturization. With commercial systems requiring 100,000 to 1,000,000 cells for successful isolation, there is a growing need for a small-footprint, easy-to-use device that can harvest nucleic acids from much smaller cell samples (1,000 to 10,000 cells). The process of extraction of RNA from cell cultures is a complex, multi-step one, and requires timed, asynchronous operations with multiple reagents/buffers. An added complexity is the fragility of RNA (subject to degradation) and its reactivity to surface.

A novel, microfluidics-based, integrated cartridge has been developed that can fully automate the complex process of RNA isolation (lyse, capture, and elute RNA) from small cell culture samples. On-cartridge cell lysis is achieved using either reagents or high-strength electric fields made possible by the miniaturized format. Traditionally, silica-based, porous-membrane formats have been used for RNA capture, requiring slow perfusion for effective capture. In this design, high efficiency capture/elution are achieved using a microsphere-based "microfluidized" format. Electrokinetic phenomena are harnessed to actively mix microspheres with the cell lysate and capture/elution buffer, providing important advantages in extraction efficiency, processing time, and operational flexibility. Successful RNA isolation was demonstrated using both suspension (HL-60) and adherent (BHK-21) cells.

Novel features associated with this development are twofold. First, novel designs that execute needed processes with improved speed and efficiency were developed. These primarily encompass electric-field-driven lysis of cells. The configurations include electrode-containing constructs, or an "electrode-less" chip design, which is easy to fabricate and mitigates fouling at the electrode surface; and the "fluidized" extraction format based on electrokinetically assisted mixing and contacting of microbeads in a shape-optimized chamber. A secondary proprietary feature is in the particular layout integrating these components to perform the desired operation of RNA isolation.

Apart from a novel functional capability, advantages of the innovation include reduced or eliminated use of toxic reagents, and operator-independent extraction of RNA.

*This work was done by Shivshankar Sundaram, Balabhaskar Prabhakarpan-dian, Kapil Pant, and Yi Wang of CFD Research Corp. for Johnson Space Center. For more information, download the Technical Support Package (free white paper) at [www.techbriefs.com/tsp](http://www.techbriefs.com/tsp) under the Bio-Medical category.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

*CFD Research Corp.*

*215 Wynn Dr.*

*Huntsville, AL 35805*

*Phone No.: (256) 726-4800*

*E-mail: [bio\\_web@cfdr.com](mailto:bio_web@cfdr.com)*

*Refer to MSC-24375-1, Medical Design Briefs, October 2012, Page 32. The purpose of this innovation is to enhance nucleation of single-wall nanotubes (SWNTs) in the HiPco process, selectively producing 10,10 tubes, something which until now has not been thought possible.*

This is accomplished by injecting C<sub>60</sub>, or a derivative of C<sub>60</sub>, solubilized in supercritical CO<sub>2</sub> together with a transition metal carbonyl co-catalyst into the HiPco reactor. This is a variant on the "supercritical" disclosure. C<sub>60</sub> has never been used to nucleate carbon nanotubes in the gas phase.

C<sub>60</sub> itself may not have adequate solubility in supercritical CO<sub>2</sub>. However, fluorinated C<sub>60</sub>, e.g., C<sub>60</sub>F<sub>36</sub>, is easy to make cheaply and should have much enhanced solubility.

*This work was done by Richard E. Smalley of Rice University for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.*

*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

*Rice University*

*Office of Technology Transfer – MS 705*

*P.O. Box 1892*

*Houston, TX 77251-1892*

*Phone No. (713) 737-6143*

*Refer to MSC-24134-1, volume and number of this NASA Tech Briefs issue, and the page number.*



# Mars Aqueous Processing System

**This technology can be used in treating soil contaminated with heavy metals and remediation of acid mine drainage.**

*Lyndon B. Johnson Space Center, Houston, Texas*

The goal of the Mars Aqueous Processing System (MAPS) is to establish a flexible process that generates multiple products that are useful for human habitation. Selectively extracting useful components into an aqueous solution, and then sequentially recovering individual constituents, can obtain a suite of refined or semi-refined products. Similarities in the bulk composition (although not necessarily of the mineralogy) of Martian and Lunar soils potentially make MAPS widely applicable. Similar process steps can be conducted on both Mars and Lunar soils while tailoring the reaction extents and recoveries to the specifics of each location.

The MAPS closed-loop process selectively extracts, and then recovers, constituents from soils using acids and bases. The emphasis on Mars involves the production of useful materials such as iron, silica, alumina, magnesia, and concrete with recovery of oxygen as a byproduct. On the Moon, similar chemistry is applied with emphasis on oxygen production.

This innovation has been demonstrated to produce high-grade materials,

such as metallic iron, aluminum oxide, magnesium oxide, and calcium oxide, from lunar and Martian soil simulants. Most of the target products exhibited purities of 80 to 90 percent or more, allowing direct use for many potential applications. Up to one-fourth of the feed soil mass was converted to metal, metal oxide, and oxygen products. The soil residue contained elevated silica content, allowing for potential additional refining and extraction for recovery of materials needed for photovoltaic, semiconductor, and glass applications.

A high-grade iron oxide concentrate derived from lunar soil simulant was used to produce a metallic iron component using a novel, combined hydrogen reduction/metal sintering technique. The part was subsequently machined and found to be structurally sound. The behavior of the lunar-simulant-derived iron product was very similar to that produced using the same methods on a Michigan iron ore concentrate, which demonstrates that lunar-derived material can be used in a manner similar to conventional terrestrial iron. Metallic

iron was also produced from the Mars soil simulant.

The aluminum and magnesium oxide products produced by MAPS from lunar and Mars soil simulants exhibited excellent thermal stability, and were shown to be capable of use for refractory oxide structural materials, or insulation at temperatures far in excess of what could be achieved using unrefined soils. These materials exhibited the refractory characteristics needed to support iron casting and forming operations, as well as other thermal processing needs.

Extraction residue samples contained up to 79 percent silica. Such samples were successfully fused into a glass that exhibited high light transmittance.

*This work was done by Mark Berggren, Cherie Wilson, Stacy Carrera, Heather Rose, Anthony Muscatello, James Kilgore, and Robert Zubrin of Pioneer Astronautics for Johnson Space Center. For more information, download the Technical Support Package (free white paper) at [www.techbriefs.com/tsp](http://www.techbriefs.com/tsp) under the Manufacturing & Prototyping category. MSC-23885-1/4362-1*